OPERATING AND MAINTENANCE

MANUAL

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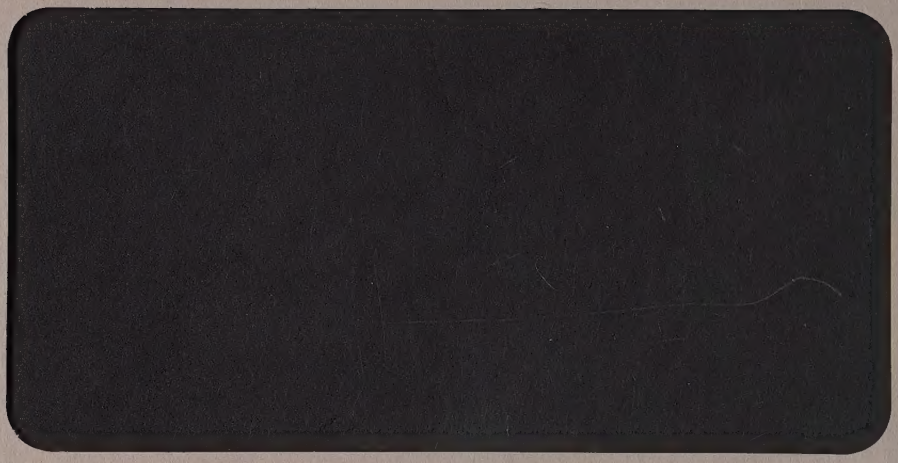

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BAND-PASS
LOW-PASS AND HIGH-PASS

VARIABLE FILTER

MODELS 314, ~~314R~~

OPERATING AND MAINTENANCE MANUAL

SERIAL NO._____

KROHN-HITE CORPORATION
580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.

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CONTENTS

Section		Page
1	GENERAL DESCRIPTION	1
2	OPERATION	5
3	CIRCUIT DESCRIPTION	7
4	MAINTENANCE	14
5	CALIBRATION AND ADJUSTMENT	19
6	PARTS LIST	30

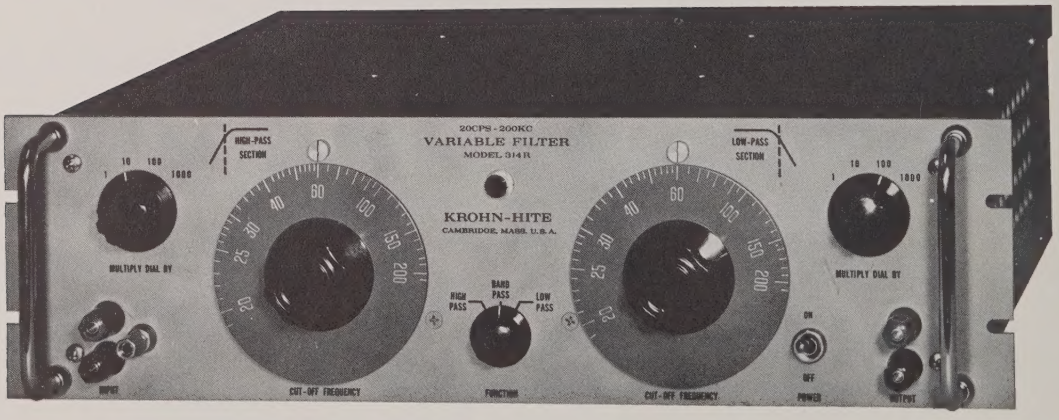
ILLUSTRATIONS

Figure		Page
1	Model 314(R) Variable Electronic Filter	ii
2	Simplified Schematic Diagram	1
3	Normalized Filter Response	2
4	Narrow Band Operation	2
5	Simplified Low-Pass Circuit	9
6	Effect of Corner Peaking	10
7	Simplified High-Pass Circuit	10
8	Effect of Corner Peaking on Pass-Band	11
9	Normalized Attenuation Characteristics	12
10	Normalized Phase Characteristics	13
11	Amplitude and Phase Characteristics	13
12	Cut-Off Frequency Gain (Band-Pass Mode)	19
13	Rear View of Dial Tuning Potentiometer Assemblies	28
14	Schematic Diagram and Voltage/Resistance Chart	Inside Back Cover

TABLES

Table		Page
1	Test Point Voltages	18
2	Detailed Test Procedure	23
3	LP and HP Potentiometer Resistance Measurements	29
4	Trim Resistor Adjustment for Tuning Potentiometers (Function Switch on Band-Pass)	29

Model 314



Model 314R

Figure 1. Model 314(R) Variable Electronic Filter

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 314(R) Filter, shown in Figure 1, is a variable electronic filter that operates from 20 cps to 200kc and is capable of being operated in any one of three functional modes; the band-pass mode, the low-pass mode, or the high-pass mode. The mode of operation is selected by means of a front panel FUNCTION switch.

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists basically of an input amplifier, a variable high-pass section, and a variable low-pass section. When operated in the band-pass mode, the high-pass and low-pass sections are connected in series. When operated in the low-pass mode, the high-pass section is by-passed and only the low-pass section is used. When operated in the high-pass mode, the low-pass section is by-passed and only the high-pass section is used. The overall gain of the Filter in the pass-band of any mode of operation is unity (0 db).

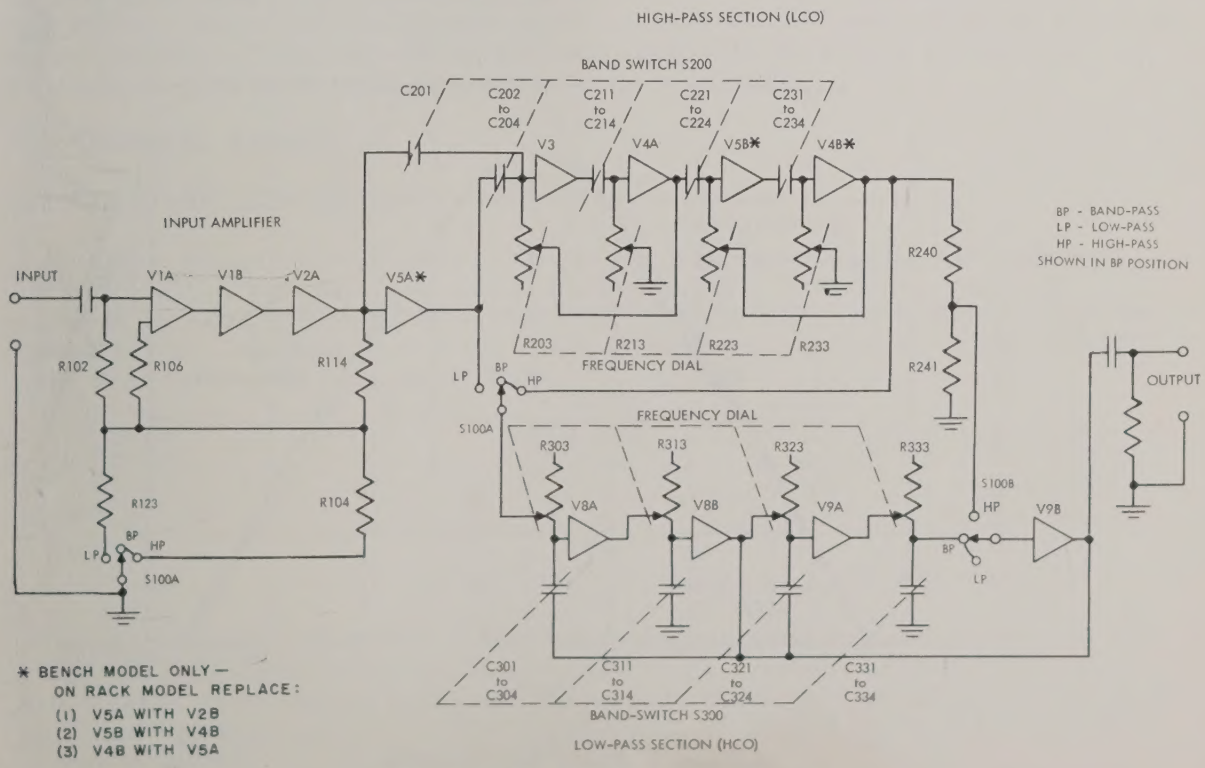


Figure 2. Simplified Schematic Diagram

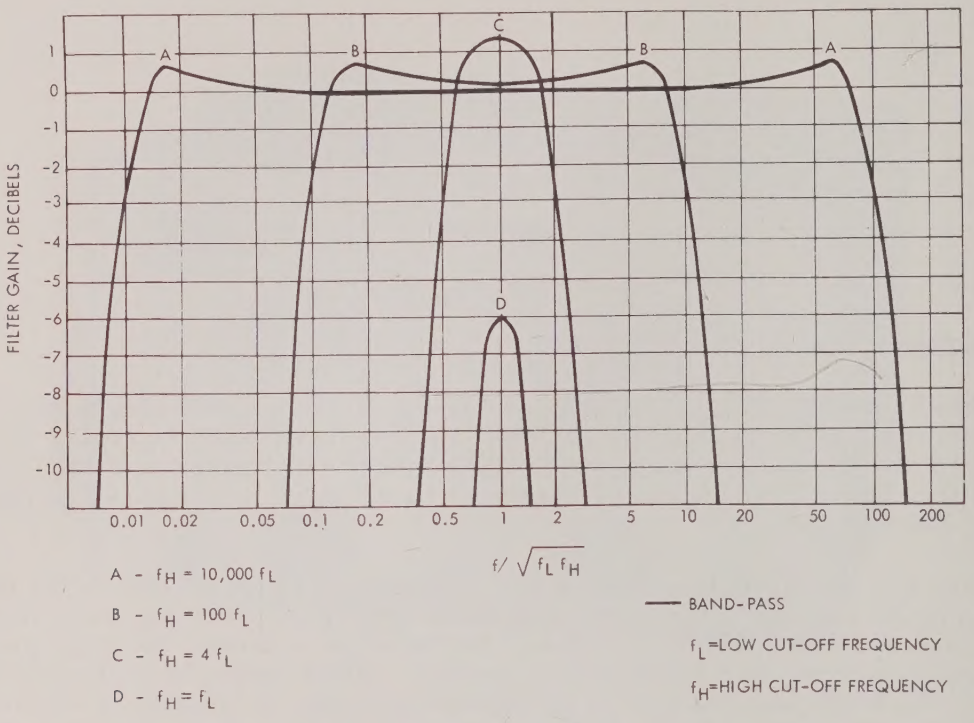


Figure 3. Normalized Filter Response

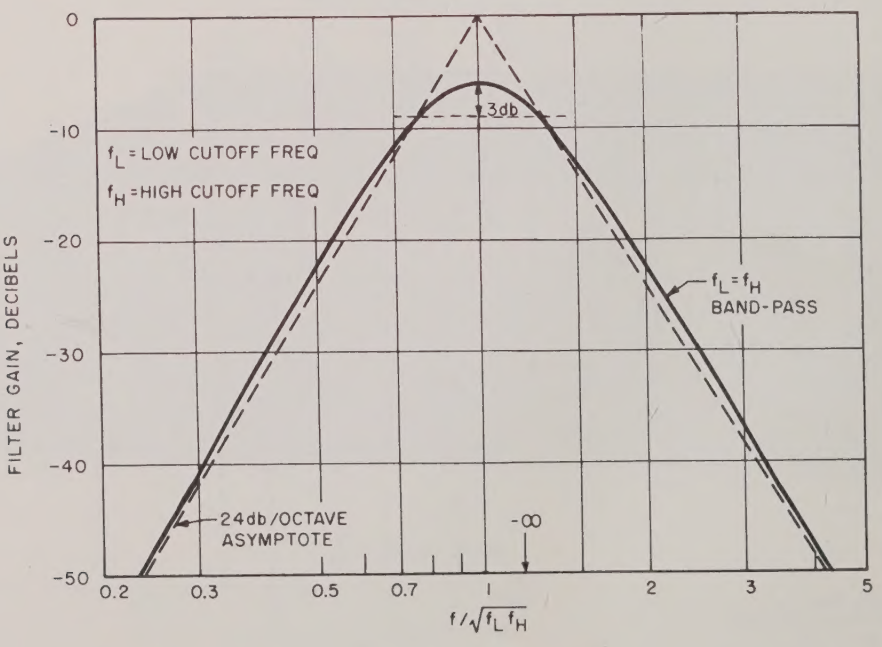


Figure 4. Narrow Band Operation

The cut-off frequency of both the high-pass and low-pass sections, when operated in the band-pass mode, is independently adjustable from 20 cps to 200kc. For low-pass or high-pass operation, only the respective cut-off frequency is variable over the 20 cps to 200kc frequency range. Operation in the band-pass mode permits the passage of frequency bands of variable width within the 20 cps to 200kc range. Operation in the high-pass mode permits passage of frequencies higher than any selected frequency within the 20 cps to 200kc range, up to the upper 3 db point of approximately 3 megacycles. Operation in the low-pass mode permits passage of frequencies lower than any selected frequency within the 20 cps to 200kc frequency range, down to the lower 3 db point of approximately 1 cps.

1.2 FILTER RESPONSE

The flexibility of adjustment of bandwidth for each of the three modes of operation is illustrated in Figure 3. Band-pass operation for four different bandwidths is illustrated by curves A, B, C, and D. High-pass operation can be represented by the left-hand portion of curves A or B when either curve is shifted to the right until it intercepts the minus 3 db point at unity normalized frequency. In this case the abscissa should be labeled f/f_H. For low-pass operation curves A or B would be shifted to the left, and the abscissa should be labeled f/f_L. As indicated by Figure 3, the mid-band gain varies for different frequency separation factors (and hence different bandwidths). The attenuation slope, (below the minus 12 db point) on the other hand, is 24 db per octave for all curves.

The minimum width of the pass-band is obtained by setting the two cut-off frequencies equal. As illustrated in Figure 4, the insertion loss is 6 db, and the minus 3 db points (half-power points) occur at 0.77 and 1.3 times the mid-band frequency. The dotted lines illustrate the 24 db/octave asymptotes intercepting the mid-band frequency or zero db point.

1.3 TECHNICAL SUMMARY

GENERAL SPECIFICATIONS

Frequency Range: Continuous coverage from 20 cps to 200kc for both high cut-off and low cut-off frequencies independently. Frequency range is covered by separate calibrated dials and four-decade band switches. Center frequency and width of pass band in band-pass mode are continuously adjustable over the entire frequency range.

Band	Multiplier	Frequency (cps)
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1000	20,000 - 200,000

Frequency Dials: Each dial is engraved and individually hand-calibrated with a single logarithmic scale reading directly in cycles per second, from 19 to 210. Dials are 4 inches in diameter with an effective scale length of 8 inches per band, giving a total effective scale length of 32 inches for the range of 20 cps to 200kc.

Accuracy of Cut-off Frequency Calibration: ±10% (±5% available on special order).

Attenuation Slope: Nominal 24 db per octave each side of pass-band with peaking factor to reduce attenuation at cut-off frequencies.

Maximum Attenuation: Greater than 60 db.

Controls: HIGH-PASS SECTION CUT-OFF FREQUENCY dial and multiplier switch. LOW-PASS SECTION CUT-OFF FREQUENCY dial and multiplier switch. FUNCTION switch. POWER OFF-ON switch.

Terminals: Front panel, two multi-purpose binding posts for the INPUT and two for the OUTPUT. Rear of chassis, two BNC type connectors, one for input and one for output. On the rack model only, an additional multi-purpose binding post for CHASSIS GROUND is provided on the front panel. Refer to NOTE in Section 2.2.

Power Requirements: 105 - 125 or 210 - 250 volts, single phase; 50 - 400 cycles; 50 watts.

Fuse Protection: 1 ampere slow-blow for 115 volts, 1/2 ampere slow-blow for 230 volts.

Form: Model 314: Dimensions: 12-1/8 inches wide, 7-3/4 inches high, and 8-3/4 inches deep. Weight: 22 lbs shipping, 19 lbs net.

Model 314R: Dimensions: 19 inches wide, 5-3/4 inches high, and 13-3/8 inches deep. Weight: 28 lbs shipping, 23 lbs net.

SPECIFICATIONS AS BAND-PASS FILTER

Bandwidth: Continuously variable up to the maximum width covering the entire frequency range from 20 cps to 200kc.

Insertion Loss: Zero db ±1 db in pass band.

Input Characteristics: Impedance: Approximately 6 megohms in parallel with 50 $\mu\mu$f. Maximum input amplitude: 5 volts rms up to 200kc, decreasing to approximately 1 volt at 500kc and 0.5 volt at 1 megacycle. Maximum dc component: 400 volts.

Output Characteristics: Impedance: Approximately 200 ohms. Maximum power: 2.5 volts rms across 500 ohms, or 12 milliwatts. Internally generated hum and noise: Less than 0.2 millivolt. (Slightly higher for 400 cps operation.)

SPECIFICATIONS AS LOW-PASS FILTER

Same specifications as band-pass filter operation, except the high-pass section is not used. The cut-off frequency is continuously adjustable from 20 cps to 200kc, and the lower 3 db point is at approximately 1 cps.

SPECIFICATIONS AS HIGH-PASS FILTER

Same specifications as band-pass filter operation, except the low-pass section is not used. The cut-off frequency is continuously adjustable from 20 cps to 200kc, and the upper 3 db point is at approximately 3 megacycles. Maximum input amplitude decreases above 200kc to approximately 1 volt at 500kc, 0.5 volt at 1 megacycle, and 0.25 volt at 2 megacycles.

NOTE

For a detailed definition of specifications refer to Section 5.1.

SECTION 2

OPERATION

2.1 INTRODUCTION

The Filter is adjusted and checked carefully before shipment to insure that it meets all specifications. It is then aged and again tested to be sure that it is ready for use. The Filter is shipped complete, and after unpacking, is ready to be turned on and used.

Unpack the Filter carefully and inspect it for damage that may have occurred during shipment. Check the case for damage, and check for loose subassemblies and parts. Make sure electron tubes are properly seated in place. Check all front panel controls for freedom of operation.

Refer to Section 1.3 for input amplitude limitations.

2.2 FRONT PANEL CONTROLS

The front panel of the Filter includes two identical frequency dials and associated multiplier switches used to set cut-off frequencies, a FUNCTION switch used to select the mode of operation, a power on-off switch and indicator light: two multi-purpose binding posts for the input signal and two for the output signal; on the rack model only, an additional multi-purpose binding post for CHASSIS GROUND is provided.

In the band-pass mode of operation, as indicated by a diagram engraved on the front panel at the side of each frequency dial, the left-hand dial (HIGH-PASS SECTION) and band multiplier switch select the low cut-off frequency while the right-hand dial (LOW-PASS SECTION) and multiplier switch select the high cut-off frequency. In high-pass operation, only the left-hand dial and multiplier are used; in low-pass operation, only the right-hand dial and multiplier are used.

Each of the two multiplier switches has four positions, covering the frequency ranges as shown in Section 1.3.

NOTE

On the rack model only - SIGNAL GROUND can be isolated from CHASSIS GROUND by removal of the shorting link provided between the metal and black binding posts on the front panel.

2.3 OPERATION

To operate the Filter, proceed as follows:

a. Make appropriate power connections as described in Section 2.5.

b. Make appropriate connections to INPUT and OUTPUT terminals of filter.

c. Turn FUNCTION switch to desired mode of operation.

d. Set cut-off frequencies by means of the band multiplier switches (CUT-OFF FREQUENCY) and the frequency dials.

e. Turn POWER switch to ON.

NOTE

For operation in the band-pass mode, the left-hand band multiplier switch and frequency dial are used to select the low cut-off frequency, and the right-hand controls select the high cut-off frequency. For operation in the low-pass mode, the cut-off frequency is selected by the right-hand controls only. For operation in the high-pass mode, the cut-off frequency is selected by the left-hand controls only.

With FUNCTION switch on BAND PASS, the minimum pass-band is obtained by setting the high cut-off frequency equal to the low cut-off frequency.

2.4 TERMINALS

INPUT - Two combination-type binding post terminals are provided on the front panel. The red terminal is used for the input signal and the black terminal for input signal ground. A parallel BNC coaxial connector is located on the rear of the chassis.

OUTPUT - Two combination-type binding post terminals are provided on the front panel. The red terminal is used for the output signal and the black terminal for output signal ground. A parallel BNC coaxial connector is located on the rear of the chassis.

CHASSIS GROUND - on the rack model only, an additional combination-type binding post is provided on the front panel. Refer to NOTE in Section 2.2.

2.5 LINE VOLTAGE AND FUSES

The Filter, as normally shipped, is connected for operation from an a-c power source of 105 to 125 volts, 50 to 400 cycles, and uses a one ampere slow-blow line fuse that is mounted on the rear of the chassis. It may be modified to operate from a 210 to 250 volt line by removing the two jumpers from the terminal barrier strip, located directly underneath the power transformer, and adding a jumper between terminals 2 and 3, refer to Figure 14. A 1/2 ampere slow-blow fuse should be used for 210-250 volt operation

SECTION 3

CIRCUIT DESCRIPTION

3.1 INTRODUCTION

The Schematic Diagram, Figure 14, of the Filter is attached to the rear cover. The darker lines on the Filter schematic show the main signal paths. As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists basically of an input amplifier, a high-pass filter section, and a low-pass filter section.

3.2 DETAILED DESCRIPTION

INPUT AMPLIFIER

The input amplifier is a multi-stage feedback amplifier that acts as a low impedance driving source to the RC circuits following it and supplies extra gain to compensate for the cathode follower losses. The first two stages (V1A and V1B) are RC coupled, and the remaining stages are direct coupled. The feedback signal is derived from the cathode of V2A, and is fed back to the cathode of V1A where it is compared to the input signal at the grid of V1A.

HIGH-PASS SECTION

This section includes four cascaded RC filter sections coupled by cathode-follower isolating stages. Each RC filter section has a critical or cut-off frequency (identical for each section) determined by the particular values of R and C, which attenuates all frequencies below the cut-off frequency at 6 db/octave and passes all frequencies above it. The cut-off frequency of all four sections is adjusted simultaneously by the ganged switches (S200A, B, C, and D) and the ganged potentiometers (R203, R213, R223, and R233). The four cascaded RC stages produce the 24 db/octave attenuation characteristic. All cathode-followers are conventional except V3 which is a two-stage "push-pull" cathode follower.

Depending on the frequency range desired, any one of four capacitors can be selected by the band multiplier switch. The frequency dial adjusts the value of resistance in the RC circuit to obtain a particular frequency within the selected range.

LOW-PASS SECTION

The low-pass section also consists of four cascaded RC filter sections coupled by isolating cathode-follower circuits. The cut-off frequency (identical for each section) is determined by the selected values of R and C. All four sections are adjusted simultaneously by the use of ganged switches (S300A, B, C, and D), and ganged potentiometers (R303, R313, R323, and R333). All frequencies below the cut-off frequency are passed while frequencies above the cut-off frequency are attenuated at 6 db/octave per section. The cascaded combination of the four RC sections results in a total attenuation of 24 db/octave.

SIGNAL PATH

The signal path in each of the three operating modes is determined by the position of FUNCTION switch, S100. The switching action, as shown in Figure 2, has been simplified for convenience in following the signal paths.

BAND-PASS MODE

When the Filter is operated in the band-pass mode (BP), the high-pass section and the low-pass section are connected in series. With FUNCTION switch, S100, on BAND-PASS, the input signal is fed through the input amplifier and then coupled to the high-pass section. From the output of the high-pass section, the signal is fed through switch S100A to the input of the low-pass section. The signal is then passed through the low-pass section and is coupled to the output terminals by switch S100B.

LOW-PASS MODE

When the filter is operated in the low-pass mode (LP), only the low-pass section is used. With FUNCTION switch S100 on LOW PASS, the input signal is coupled through the input amplifier to the low-pass section. The output of the low-pass section is coupled by S100B, through V9B, to the output terminals.

HIGH-PASS MODE

When the Filter is operated in the high-pass mode (HP), only the high-pass section is used. With FUNCTION switch S100 on HIGH PASS, the input signal is coupled through the input amplifier to the high-pass section. From the output of the high-pass section, the signal is coupled by switch S100B, through V9B, to the output terminals.

POWER SUPPLY

The power supply employs a full-wave rectifier, a filter network, and a series voltage regulator. Voltage regulation is accomplished by tubes V7 and V2B (V5B on rack model). Any change in the B+ is sensed by the grid of V2B (V5B on rack model) resulting in a change in current flow through this tube. This change in current changes the voltage at the control grid of V7 which causes a change in current flow through this tube in such a manner as to counteract the original change in B+. Thus, the series regulator compensates for line voltage fluctuations, further reducing the output noise of the filter.

3.3 PRINCIPLES OF OPERATION

LOW-PASS FILTER SECTION

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists of an input amplifier, a high-pass filter section and a low-pass filter section. The low-pass filter section consists of two similar low-pass circuits connected in series. The simplified schematic of one low-pass circuit is shown in Figure 5.

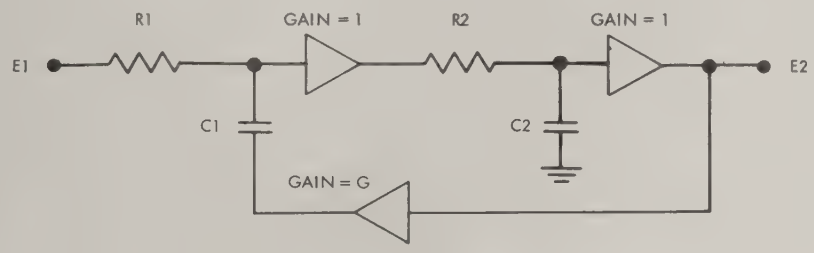


Figure 5. Simplified Low-Pass Circuit

A portion of the output signal $G E_2$ is fed back to the first capacitor C1. If both capacitors and resistors are equal, the circuit has a transfer function of:

$$\frac{E_2}{E_1} = \frac{1}{j^2\omega^2 R^2C^2 + j\omega R C (2-G) + 1}$$

At the cut-off frequency where $j^2\omega^2 R^2C^2 + 1 = 0$ or $\omega_{co} = 1/RC$ the gain of the circuit becomes $1/(2-G)$. The peaking of the response curve for three different values of the peaking factor A is shown in Figure 6, where $A = 1 - G/2$.

The middle curve is used in the Filter and is obtained by setting the peaking factor A to approximately 0.6 which corresponds to a gain G of approximately 0.8. This results in a gain of approximately minus 1.5 db at the cut-off frequency, and an attenuation slope of 12 db/octave for each low-pass circuit. The two similar circuits combine to achieve a gain of minus 3 db at the cut-off frequency and an attenuation slope of 24 db/octave.

HIGH-PASS FILTER SECTION

The high-pass filter section is composed of two similar high-pass circuits. The basic circuit is shown in Figure 7.

The feedback signal GE_2 is fed to the first amplifier through resistor R1. If both capacitors and resistors are equal the circuit has a transfer function of:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R^2C^2}{j^2\omega^2 R^2C^2 + j\omega R C (2-G) + 1}$$

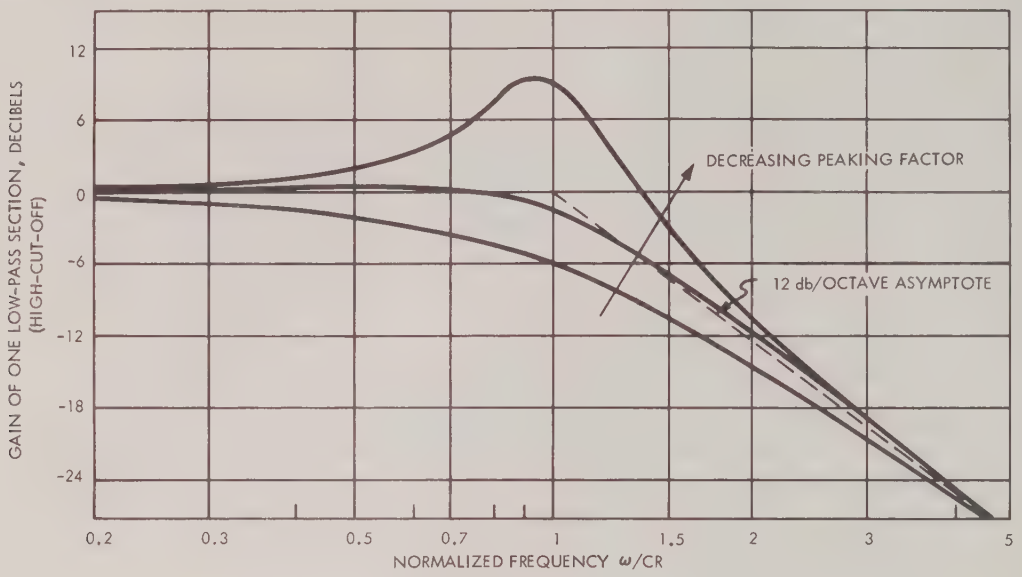


Figure 6. Effect of Corner Peaking

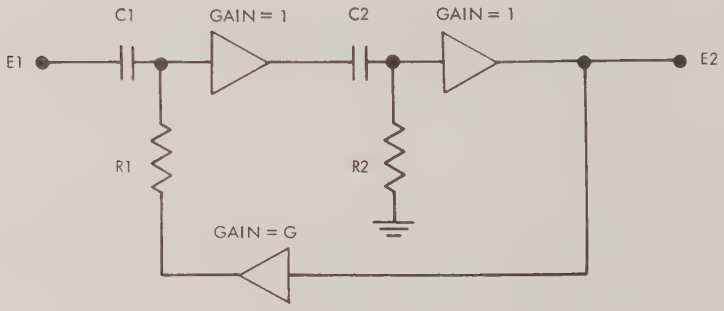


Figure 7. Simplified High-Pass Circuit

At the cut-off frequency where $\omega_{co} = 1/CR$ the gain of the circuit becomes $1/(2-G)$.

The response curves of one high-pass circuit are symmetrical to the curves shown in Figure 6 about the axis of normalized frequency of unity. The middle curve is used in the Filter and is obtained by setting the peaking factor A to approximately 0.6 giving a gain of approximately minus 1.5 db at the cut-off frequency, and an attenuation slope of 12 db/octave for each high-pass circuit. The two similar circuits combine to achieve minus 3 db at the cut-off frequency and an attenuation slope of 24 db/octave.

EFFECTS OF PEAKING FACTOR

Choosing a peaking factor of approximately 0.6 obtained by selecting a gain of approximately 0.4 in the feedback amplifier results in a relatively small (0.75 db) peaks in the attenuation curve, but reduces the corner frequency attenuation by 9 db from that obtained from four independent RC sections

with unity peaking factor. For most applications, the Filter is superior because of the higher gain near the corner frequencies. Figure 8 shows a typical band-pass characteristic for a low cut-off frequency of 40 cps, and a high cut-off frequency of 160 cps. The response of the Filter is shown by the solid curve, and the response of a filter without a peaking feedback loop is shown by the dashed curve.

TRANSFER FUNCTIONS

The transfer functions (output voltage over input voltage) for the three modes of operation can be expressed as follows:

$$\text{BAND-PASS:} \quad \frac{\omega^4 T_1^4}{(1 + 2j A \omega T_1 - \omega^2 T_1^2)^2 \ (1 + 2j A \omega T_2 - \omega^2 T_2^2)^2}$$

$$\text{LOW-PASS:} \quad \frac{1}{(1 + 2j A \omega T_1 - \omega^2 T_1^2)^2}$$

$$\text{HIGH-PASS:} \quad \frac{\omega^4 T_1^4}{(1 + 2j A \omega T_1 - \omega^2 T_1^2)^2}$$

where the low cut-off frequency is $1/2 \ \pi T_1$ and the high cut-off frequency is $1/2 \ \pi T_2$. The value of the peaking factor A, which is normally unity for filters composed of independent resistance-capacitance elements, is fixed at approximately 0.6. This value produces gain-peaks of approximately 0.75 db and reduced attenuation at the cut-off frequencies compared to the attenuation of a filter with unity peaking factor.

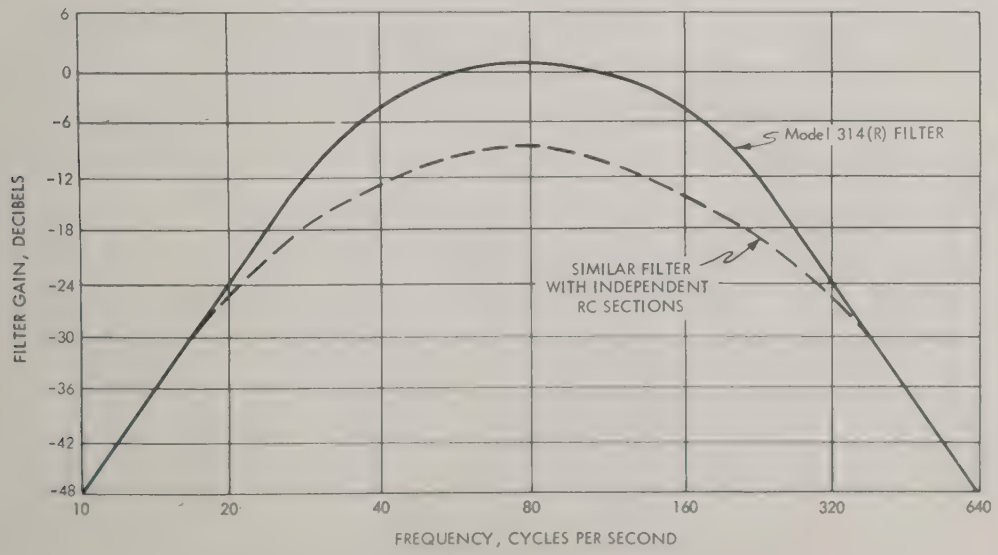


Figure 8. Effect of Corner Peaking on Pass-Band

3.4 GENERALIZED FILTER CHARACTERISTICS

The gain and phase characteristics of the Filter for any one of the three operating modes can be plotted from the curves shown in Figures 9 and 10.

BAND-PASS MODE

The gain at any frequency is the sum of the gains (in decibels) of the high and low cut-off attenuation curves. For example as shown in Figure 9, if the cut-off frequencies are separated by a factor of four, the high cut-off frequency is at $f/f_H = 1$, the mid-band frequency (geometric mean of high and low cut-off frequencies as shown in Figure 3) is at $f/f_H = 0.5$, and the mid-band gain is 0.75 db. The low cut-off frequency is at $f_L/f = 1$, the mid-band frequency is at $f_L/f = 0.5$, and the mid-band gain is 0.75 db. The total mid-frequency gain is then 1.5 db. The gain at the high cut-off frequency is minus 3 db due to the low-pass section ($f/f_H = 1$), and 0.3 db due to the high-pass section ($f_L/f = 0.25$), resulting in a total gain of minus 2.7 db. Also, the gain at the low cut-off frequency is minus 2.7 db because the two attenuation curves are symmetrical about the mid-band frequency. As many other points as required can be similarly obtained from Figure 9.

The phase angle at any frequency is the sum of the angles due to the high and low cut-off attenuation curves. For example, as shown in Figure 10, if the cut-off frequencies are separated by a factor of four, the phase angle due to the low-pass section is approximately minus 180° at the high cut-off frequency ($f/f_H = 1$), minus 80° at mid-band ($f/f_H = 0.5$) and minus 30° at the low cut-off frequency ($f/f_H = 0.25$). The phase angle due to the high-pass

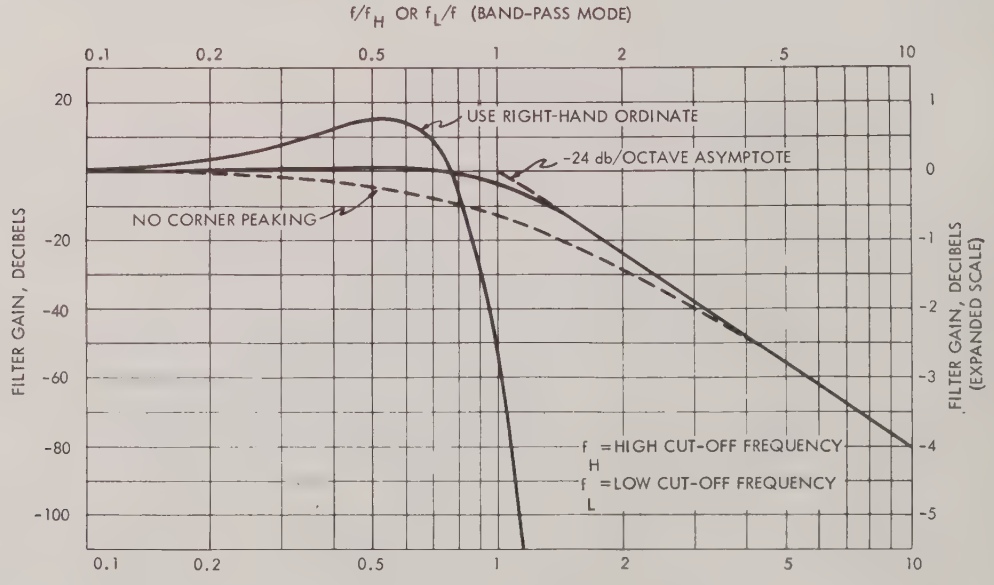


Figure 9. Normalized Attenuation Characteristics

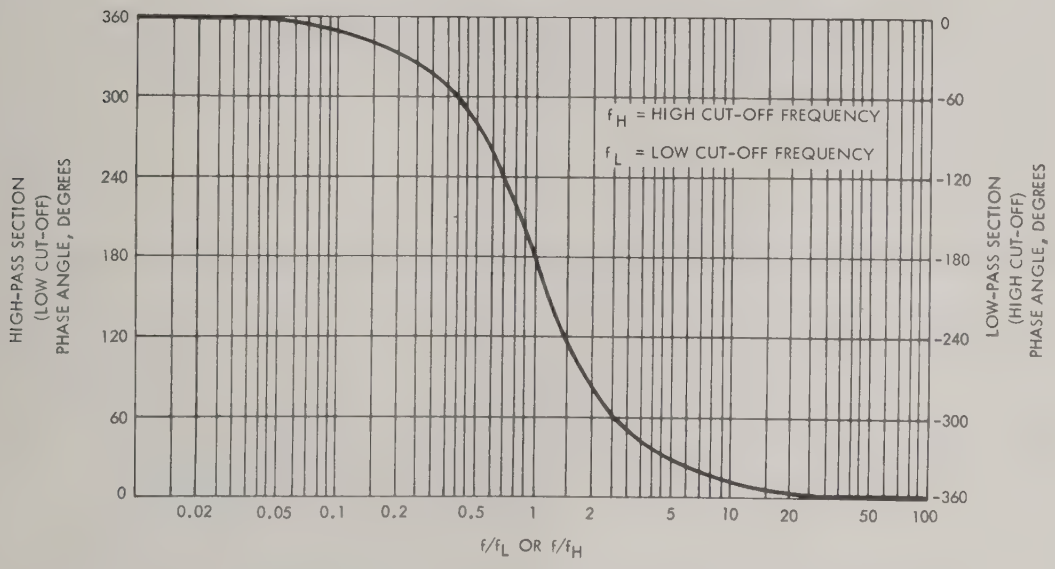


Figure 10. Normalized Phase Characteristics

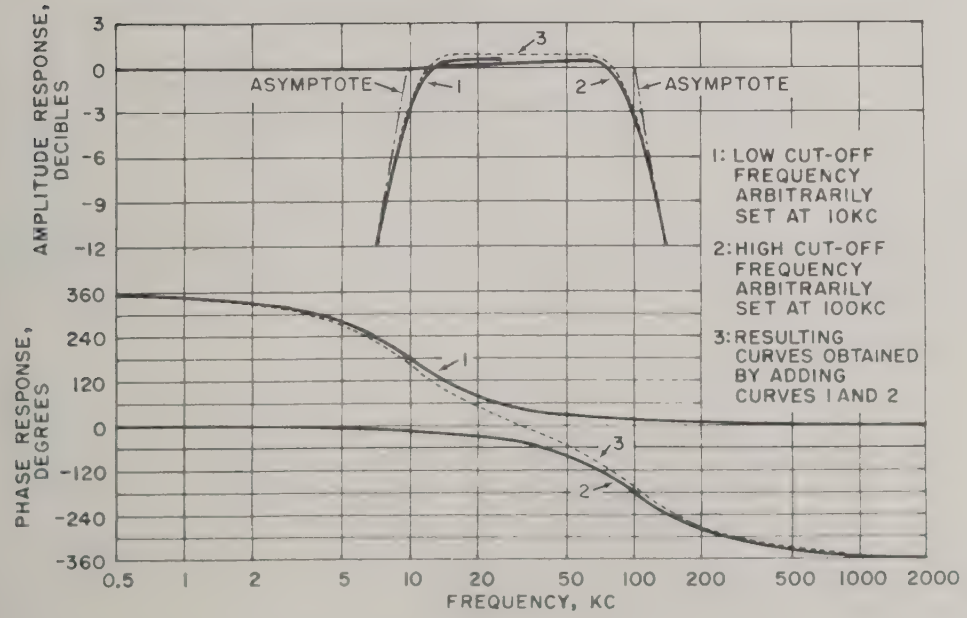


Figure 11. Amplitude and Phase Characteristics

section is approximately plus 30° at the high cut-off frequency ($f/f_L = 4$), plus 80° at mid-band ($f/f_L = 2$), and plus 180° at the low cut-off frequency ($f/f_L = 1$). Therefore, the total phase angle is minus 150° at the high cut-off frequency, zero at mid-band, and plus 150° at the low cut-off frequency. Phase angles at other frequencies can be similarly obtained from Figure 10.

LOW-PASS MODE

When the Filter is used in the low-pass mode, gain can be plotted from Figure 9 directly. The desired cut-off frequency is set at unity on the abscissa and gain is read from the appropriate ordinate scale. Phase angle is obtained from Figure 10 by using the abscissa and right-hand ordinates.

HIGH-PASS MODE

When the Filter is used in the high-pass mode, the gain can be plotted from Figure 9 by considering either one of the abscissas labeled "f_H/f" or "f_L/f". The desired cut-off frequency is at unity, and the curve is symmetrical to the one shown about the unity point on the abscissa. Phase angle is obtained from Figure 10 by using the abscissa and the left-hand ordinates.

An example of Filter characteristics in band-pass mode for a frequency separation factor of 10 is shown in Figure 11. The low cut-off frequency is at 10kc, the mid-band frequency at 31.6kc (geometric mean of high and low cut-off frequencies) and the high cut-off frequency is at 100kc.

SECTION 4

MAINTENANCE

4.1 INTRODUCTION

All components in the Filter are of the highest quality and should have a long trouble-free life because they are operated well below their design ratings. The following procedure facilitates locating the source of trouble if the Filter does not function properly.

NOTE

To gain access to the interior of the filter: (1) On the bench model - remove the two lower inner-most screws from the rear plate and slide the chassis out from the front of the cabinet. (2) On the rack model - remove the screws securing the dust covers to the chassis; remove dust covers.

4.2 TUBE COMPLEMENT CHECK

Before performing any maintenance, turn on the Filter, and make certain that the correct tubes are inserted properly in their respective sockets. Apply power to the Filter, and note whether the filiments of the tubes are lit.

If any of the filaments of any tube fail to light after a sufficient warm up time, replace the tube.

The likeliest source of instrument failure is the vacuum tubes since they have an inherently shorter life. Therefore, if the Filter fails to operate after the initial tube check described above, install new tubes as required. The type number of each tube is clearly marked on the chassis adjacent to the tube.

4.3 FUSE FAILURE

A cartridge fuse (1 amp at 115 vac, 1/2 amp at 230 vac), located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuits. The rating of this fuse is selected for proper protection of the instrument and the fuse should be replaced with one of the same type and rating.

If a fuse failure is detected, the following procedure is recommended before replacing the fuse:

a. Remove the rectifier tube, V6, and disconnect the power cord. Measure the dc primary resistance of the power transformer which should be approximately 5 ohms with the primary jumpered for 115 vac, and approximately 20 ohms with the primary jumpered for 230 vac. A lower resistance reading probably indicates a shorted primary.

b. Insert a new fuse, connect the power, and then, with V6 still out, check the primary and the secondary voltages of the transformer. If the voltages are correct, the transformer is functioning properly.

c. Prior to inserting a new rectifier tube, disconnect the power and check the dual filter capacitor, C503. A shorted capacitor can be detected by connecting an ohmmeter (low range) directly across it. If these capacitors are not shorted, check the unregulated positive 335 volt supply and regulated positive 265 volt supply to determine if they are shorted to each other, or individually to ground. The unregulated positive 335 volts can be measured conveniently at the plate of V7. The regulated positive 265 volts can be measured at the plates of V4.

d. If the above procedure has not uncovered any faulty components or wiring, the rectifier tube may be the cause of the trouble and should be replaced.

4.4 POWER SUPPLY

If the instrument is not functioning when the rated line voltage is applied and the instrument is powered as indicated by the pilot light or visible tube filaments, it is advisable to check the power supply.

The positive (+) unregulated supply voltage, as derived from the cathode of the rectifier tube, V6, is filtered in a capacitor-input, single-section, pi-filter consisting of C503 and L501. The unregulated supply voltage at rated line voltage should be approximately +335 volts.

If the unregulated voltage deviates from its proper value, replace the rectifier, V6. If after replacing V6 there is no change in the voltage level, check the total current drain by measuring the voltage across L501 which, under normal conditions, should be approximately 25 volts. If the voltage is appreciably higher than normal, the equipment is drawing excessive current. The excessive current may be due to a low-resistance path in the dual filter capacitor C503 or to incorrect d-c output level of the input amplifier or cathode followers.

Since both stages of the a-c regulator are RC coupled, their d-c levels are independent so that the voltage levels of each stage can be checked independently according to the Voltage/Resistance Chart, Figure 14. Too large a voltage drop across V7 suggests excessive grid bias which could be caused by C504 leakage. The plate voltage of V2B (V5B on rack model) may vary considerably from the indicated value as shown in the Voltage and Resistance chart since this tube derives its bias from grid current which varies from tube to tube.

4.5 INPUT AMPLIFIER (BAND PASS MODE)

Due to RC coupling from the plate of V1A to the grid of V1B, there is no d-c feedback and the d-c levels are determined as follows:

V1B grid is at 0 volts.

R111 and R112 set the voltages of V1B plate and cathode.

Voltage at V1B plate appears on V2A grid. (No current flows through parasitic suppressor R113.)

Voltage at V2A cathode should be only a few volts more positive than V2A grid due to cathode follower action.

Voltage at V1A cathode is set by voltage at V2A cathode and voltage divider resistors, R104 and R114, in cathode of V2A.

Voltage on cathode of V2A is divided down by R117 and R126 and is used to set grid of V5A (V2B on rack model) Cathode - follower action sets the cathode a few volts higher.

Voltage at V1A plate is determined by voltage at V1A cathode and resistors R106 and R107.

A malfunction in the input amplifier can be found quickly if the voltages are checked in the order described.

4.6 REMAINING STAGES (BAND PASS MODE)

All of the remaining stages are types of cathode followers. Stage V3 can be considered as a cathode follower by considering the bottom tube to be a simple d-c resistance.

In all cases, due to cathode-follower action, the cathode of each stage will be a few volts higher than the grid of the same stage if the circuit is working properly. The cathode-followers are coupled in the following order:

R214 and R215 set voltage at V4A grid.

Cathode-follower action sets V4A cathode a few volts higher.

Voltage at V4A cathode is divided down by R217 and R218 and is used to set the level of V3 grid. Due to cathode-follower action, this also sets level of V3A cathode and V3B plate a few volts higher. V3B grid is at zero volts and its cathode should be a few volts higher.

R234 and R235 set voltage at V4B (V5A on rack model) grid.

Cathode-follower action sets the cathode, a few volts higher.

This cathode voltage is divided down by R237 and R239 and is used to set level of V5B (V4B on rack model) grid. As above, the cathode level is set a few volts higher.

R305 and R307 set voltage at V8A grid.

Voltage at junction of R308 and R309, which is approximately at the same voltage as the V8A cathode is fed to V8B grid. This sets voltage of V8B cathode a few volts higher.

Voltage at V8B cathode sets voltage at V9A grid, at same value. This sets voltage at V9A cathode a few volts higher.

With FUNCTION switch, S100, on LOW PASS or BAND PASS, voltage at V9A cathode sets voltage at V9B grid at same value. This sets voltage at V9B cathode, a few volts higher.

With FUNCTION switch, S100, on HIGH PASS, voltage at V4B (V5A on rack model) cathode is divided by R240 and R241 and sets voltage at V9B grid. This sets voltage at V9B cathode, a few volts higher.

Any break in these chains of slowly rising voltages from grid to cathode to grid to cathode indicates that the stage, or its associated circuitry, is malfunctioning and should be carefully checked.

4.7 SIGNAL TRACING ANALYSIS

With the FUNCTION switch on BAND PASS, apply a 2,000 cps, 5 volt, rms sine wave to the INPUT of the filter. Set the HIGH PASS SECTION CUT-OFF FREQUENCY to 20 cps and the LOW PASS SECTION CUT-OFF FREQUENCY to 200kc. When the instrument is operating properly this 2,000 cps test signal will pass through the Filter unchanged and appear at the OUTPUT with equal amplitude. If the test signal does not appear at the OUTPUT of the Filter it is advisable to first localize the malfunction by determining where the test signal fails to appear within the instrument.

Test points in the Filter with their correct signal voltages are listed in Table 1, for a 5 volt rms sine wave input. If the test point voltage differs appreciably from the correct voltage, all of the components, wiring, and voltage and resistance readings to ground associated with the tube(s) preceding the test point should be checked.

TABLE 1

TEST POINT VOLTAGES

Test Point		Correct Signal Voltage
Tube No.	Pin No.	
V1A	PLATE	0.7
V1B	PLATE	19
V2A	CATHODE	18.5
V3A	CATHODE	7.0
V4A	CATHODE	6.8
V5B (V4B on rack model)	CATHODE	6.5
V4B (V5B on rack model)	CATHODE	6.3
V8A	CATHODE	6.1
V8B	CATHODE	5.8
V9A	CATHODE	5.5
V9B	CATHODE	5.0
LOW CUT-OFF Frequency: 20 cps HIGH CUT-OFF Frequency: 200 kc INPUT: 5V rms at 2,000 cps		

4.8 TUNING CIRCUITS

The tuning capacitors are switched four at a time by the multiplier switches (S200 and S300) as shown in Figure 14. The tuning resistances are varied by the tuning dial that turns four potentiometers through a system of gears. The trim resistors and angular orientation of these potentiometers are carefully adjusted at the factory for proper tracking and tuning. No attempt should be made to replace the potentiometers, since such replacement would require calibrating a new dial. The trim resistors can be replaced after repair according to instructions in the detailed test procedures given in Table 2 of Section 5.

SECTION 5

CALIBRATION AND ADJUSTMENT

5.1 INTRODUCTION

When testing the Filter for its conformance to operating specifications or if the Filter is scheduled for periodic calibration the following should be observed:

CUT-OFF FREQUENCY CALIBRATION

The high and low cut-off frequencies, as defined below, should be within ±10% of the corresponding dial reading. KROHN-HITE Electronic Filters are calibrated to conform to the following:

From passive Filter terminology, the cut-off frequency is the frequency at which the gain of the Filter is 3 db down from the gain at the middle of the pass-band (band-pass mode), or 3 db down from the zero db reference (low-pass and high-pass modes). When checking the cut-off frequency calibration accuracy as defined above refer to Figure 12. Cut-off frequency gain is the amount by which the Filter output at the cut-off frequency differs from the mid-band or mean frequency output. This gain varies with separation of the cut-off frequencies and is plotted in Figure 12 as a function of the ratio of high to low cut-off frequencies. Cut-off frequency gain approaches minus 3 db for wide separations (curve A of Figure 3), has a maximum of about minus 4.2 db for a separation factor of four (curve C of Figure 3), and goes to zero db when the cut-off frequencies coincide (curve D of Figure 3).

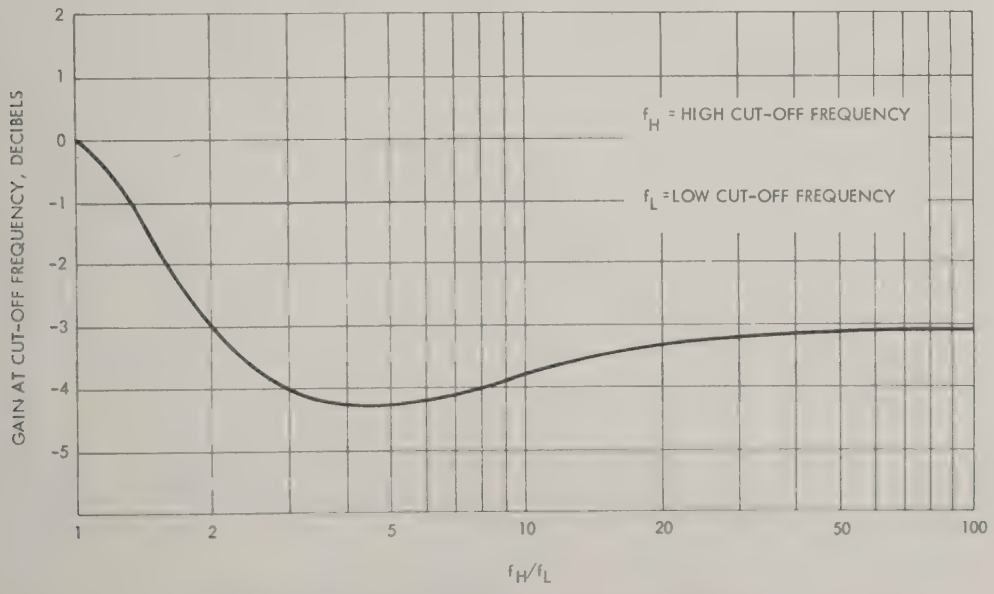


Figure 12. Cut-Off Frequency Gain (Band-Pass Mode)

INSERTION LOSS

In the band-pass mode, the Filter output voltage under open circuit conditions will be within ±1 db of the input voltage for all frequencies within the pass-band. The pass-band, for the purpose of specifying insertion loss, is defined as the frequency spectrum from ten times the low cut-off frequency setting to one tenth of the high cut-off frequency setting. To determine the insertion loss (pass-band gain) accurately, the high and low cut-off frequencies must be separated by a factor of at least one hundred, and the measuring frequency must be the geometric mean of these frequencies.

In the low-pass mode, the Filter output voltage under open circuit conditions will be within ±1 db of the input voltage for all frequencies from the lower 3 db point to one-tenth of the low cut-off frequency setting.

In the high-pass mode, the Filter output voltage under open-circuit conditions will be within ±1 db of the input voltage for all frequencies up to the upper 3 db point. The gain is measured at ten times the cut-off frequency for the purpose of specifying insertion loss.

ATTENUATION SLOPE

A typical attenuation curve is shown in Figure 9. At the cut-off frequency, the slope is approximately 12 db per octave, and at the 12 db point the slope has essentially reached its nominal value of 24 db per octave. The slope of the straight portion of the curve may be slightly less than 24 db per octave at certain frequencies because of cross-coupling effects.

INTERNAL IMPEDANCE

The rated internal impedance is the effective source impedance. In KROHN-HITE Electronic Filters there is no requirement for the load impedance to match the output impedance. Refer to Section 1.3 for output signal voltage and power limitations.

INTERNALLY GENERATED HUM AND NOISE

The internally generated hum and noise measurement is based on the use of a Ballantine Model 310 Voltmeter, or equivalent. The measurement is made with the INPUT terminals connected by a shorting jumper, no other external signal connections to the instrument, and the voltmeter leads shielded.

DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the Filter is operated within its ratings, distortion products introduced by the Filter and not present in the INPUT signal will not exceed 0.5% of the OUTPUT signal. In most cases distortion will be considerably less than 0.5%.

TRANSIENT RESPONSE

The term transient response is sometimes used in reference to filters in an attempt to specify performance when impulse voltages are applied to the input. Mathematical analysis and laboratory measurements show that for a given input signal (complex wave, square wave, step function, etc.) all Filters will produce an output signal that depends only on the transfer function vs. frequency and is not affected in any manner by the electrical composition of the Filter (RC, m-derived, etc.). The phase and/or amplitude of the individual input signal frequency components may, however, suffer undue distortion at the output if the Filter does not have a smooth transfer characteristic with no pronounced peaks. Distortion of this nature is minimized by the design of KROHN-HITE Filters. These Filters represent the optimum practical approach to ideal Filter characteristics combined with versatility to give unsurpassed perfomance.

5.2 DETAILED TEST PROCEDURE

GENERAL

1. All d-c voltage measurements should be made with a VTVM, and made with respect to ground (chassis), unless otherwise specified.

2. All measurements should be made with a line voltage having less than 1% distortion.

3. Give the instrument a thorough visual inspection, looking particularly for oil leaks, discoloration of the chassis, component panels, or components, and loose or broken wires, poor solder connections, etc.

4. Check that all tubes are seated firmly in the correct sockets and that all heaters light.

5. Check operation of POWER switch.

6. Filter must be operated at rated line voltage.

7. Check that wires do not touch the gears and that the dials rotate smoothly.

TEST EQUIPMENT REQUIRED

1. Audio Oscillator - capable of supplying at least 10 volts rms from 10 cps to 3 megacycles with frequency calibration better than ±2% and distortion less than 1%. (Frequency may be checked with a frequency counter.)

2. A-C Millivoltmeter - reading from 10 mv full scale to 10 volts (rms) full scale (db scale desirable), with a frequency response from 10 cps to 3 megacycles.

3. Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 2 kc and vertical sensitivity of 10 mv per division.

4. Vacuum Tube Voltmeter - reading to 500 volts dc.

5. Variable Auto-transformer - to adjust the line voltage.

6. A-C Voltmeter - to measure line voltage.

7. Resistance bridge - accuracy of at least 1%.

VOLTAGE MEASUREMENTS (BAND-PASS MODE: LINE VOLTAGE SET TO 115/230 VOLTS):

1. Voltage measurement of B plus. Read d-c voltage at the plates of V4.
   Tolerance: +265 volts ±20%

2. Voltage measurement of input amplifier operating point. Read d-c voltage on plate of V1A.
   Tolerance: +160 volts ±20%

3. Voltage measurement of input amplifier operating point. Read d-c voltage on plate of V1B
   Tolerance: +110 volts ±20%

4. Voltage measurement of OUTPUT d-c level. Read d-c voltage across OUTPUT terminals.
   Tolerance: zero to plus 0.15 volt.

   If readings are incorrect, check output circuit and capacitor C405.

TEST PROCEDURES

Table 2 contains detailed test procedures to check Filter performance. The procedures are to be performed in the given order. Throughout the procedures, "low-pass" is abbreviated "LP" and "high-pass" is abbreviated "HP". Note that LOW-PASS dial and multiplier refers to the right-hand frequency dial and band multiplier switch, and that HIGH-PASS dial and multiplier refers to the left-hand frequency dial and band multiplier switch.

TABLE 2. DETAILED TEST PROCEDURE

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
1a.	Overall operation check	BP	19	X10	210	X100	2.5	2kc
	Output signal should be from 2.25 to 2.75 volts.							
b.	Same	BP	19	X10	210	X100	2.5	20 cps
	Output signal should be less than 5 millivolts.							
2.	Input loop adjustment	BP	20	X1	200	X1000	2.0	2kc
	With an ac VTVM, compare the ac signal on the cathode of V4B (V5A on rack model) with the signal on the filter output. The difference between the two magnitudes should be approximately 3.0 db. Record this deviation as "A". Change the HP SECTION Multiplier to X1000 and change the incoming signal frequency to 200kc. Adjust the input signal level until the signal measured on the cathode of V4B (V5A on rack model) equals 2 volts rms plus reading "A". Measure the signal on the cathode of V2A and record this as "B". Change the input frequency to 2kc and re-adjust the input voltage level to 2.0 volts rms. Change the value of trim resistor, R104, if necessary so that the signal measured on the cathode of V2A equals reading "B" ±0.5 db.							
3.	Gain Adj. - H. P. Mode	HP	20	X1	200	X1000	0.5	2000 cps
	Check the insertion loss through the filter from input to output. Adjust the value of R117 if necessary for zero insertion loss ±1.0 db. Sweep the input frequency from 2kc to 200kc. Adjust C117, if necessary, for a flat response within ±0.5 db measured on the cathode of V2A. With the input frequency set to 200 kc, set the HP SECTION multiplier switch to X1000 and adjust C240 if necessary for zero insertion loss ±1.0 db from input to output. Switch the HP SECTION Multiplier to X1 and adjust C128, if necessary, for zero insertion loss ±1.0 db.							
4.	Gain Adj. - L. P. Mode	LP	20	X1	200	X100	0.5	1kc
	Check the insertion loss from input to output. Change the value of R123 if necessary for zero insertion loss ±0.5 db. Switch LP SECTION frequency multiplier to X1000 and observe change in output. Tolerance ±0.5 db. Adjust C124 if necessary to maintain zero insertion loss ±0.5 db.							
5.	Frequency Response	HP	20	X1	20	X1	0.5	2kc - 3 mc
	Sweep input frequency from 2kc to 3 mc. The Output should be flat ±1db and approximately -3 db at 3 megacycles.							
6.	Output impedance	BP	19	X1	210	X100	2.5	200cps
	Connect a 500-ohm resistor across OUTPUT terminals. Output signal should be 1.6 to 1.8 volts. Remove 500 ohm resistor.							
7.	Corner peaking, Low-pass frequency	BP	60	X1	60	X100	2.5	300cps
	Read output signal in db. Switch LP SECTION frequency multiplier to X10 position, and read new value of output signal in db. Tolerance is zero to +1.5 db change from first reading.							
8.	Corner peaking, High-pass frequency	BP	60	X1	60	X100	2.5	1200 cps
	Read output signal in db. Switch HP SECTION frequency multiplier to X10 position, and read new value of output signal in db. Tolerance is zero to +1.5 db change from first reading.							
9.	Overload amplitude	BP	190	X1	210	X10	--	600 cps
	Set oscillator amplitude just below point at which scope begins to show distortion. Output signal should be greater than 5 volts and not distorted.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
10.	Check leakage of input coupling capacitor	BP	190	X1	210	X10	5	600 cps
	Connect oscillator to INPUT terminals through a 1 μf capacitor which has a leakage resistance greater than 100 megohms. Connect top INPUT terminal to plate of V8A (plus 265 volts) through a 1 megohm resistor. Set oscillator amplitude just below point at which scope begins to show distortion. Output signal must be greater than 5 volts. Note: An external source of plus 270 volts may be used for this step. Allow ample time for the capacitors to charge.							
11.	Gain change vs. HP tuning, BP Mode	BP	190 -19	X1	210	X1000	2.5	2kc
	Rotate HP SECTION dial slowly from 190 to 19, and observe any changes in output voltage. Tolerance is 0 ±0.5 db.							
12.	Gain changes vs. HP band switching	BP	19	X1	210	X1000	2.5	100kc
	Switch HP SECTION frequency multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is 0 ±0.5 db.							
13.	Insertion loss outside the rejection region	HP	19	X1	210	X1000	2.5	500kc
	Switch HP SECTION frequency multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is 0 ±0.5 db.							
14.	Filter gain at upper frequency limit	BP	19	X1	210	X1000	2.5	200kc
	Output signal should be greater than 0.5 volt.							
15.	Filter gain at lower frequency limit	BP	19	X1	210	X1	2.5	20 cps
	Output signal should be greater than 0.5 volt.							
16.	Output hum and noise	BP	30	X1	120	X1	Short Circuit	--
	Short INPUT using a short lead, and shield bottom of chassis if necessary; use shielded connecting cables. Noise signal should be less than 200 microvolts.							
17.	10 cps maximum attenuation below pass-band frequency	BP	200	X1000	200	X1000	2.5	10 cps
	Output signal should be less than 0.0025 volt.							
18.	20 kc maximum attenuation below pass-band frequency	BP	200	X1000	200	X1000	2.5	20kc
	Output signal should be less than 0.0025 volt.							
19.	20 kc maximum attenuation above pass-band frequency	BP	200	X10	200	X10	2.5	20kc
	Output signal should be less than 0.0025 volt.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
20.	Check test oscilloscope phase shift at 2000 cps. Set oscillator for 5 volts at 2000 cps							
	Connect scope horizontal input to oscillator output, and adjust scope for a sweep 20 divisions wide; remove scope horizontal input. Connect scope vertical input to oscillator output, and adjust scope for a line 20 divisions high. Connect both horizontal and vertical inputs to oscillator and check for equal horizontal and vertical phase shift in scope amplifier by noting a completely closed ellipse (straight line) at about a 45-degree angle. Note: For all calibration steps 21 through 34: (1) connect a 1500 ohm resistor across the Filter OUTPUT terminals, (2) for ±5% Calibration units, reduce tolerances by one-half							
21.	Check phase calibration of HP dial at 600 cps	BP	60	X10	210	X1000	5	600 cps
	Connect scope vertical input to cathode of V4B (V5A on rack model), and connect horizontal input to cathode of V5A (V2B on rack model) through 10 μf (non-polarized) capacitors to remove dc levels. Adjust the HP SECTION dial to close the ellipse at approximately a 135 degree angle. Tolerance is a dial setting of 54 to 66. If out of tolerance, loosen set-screws and reset dial.							
22.	3 db attenuation calibration of HP dial at 600 cps	BP	60	X10	210	X1000	5	600 cps
	Switch the HP SECTION frequency multiplier to the X1 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the HP SECTION frequency multiplier to the X10 position; adjust the HP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 54 to 66. If out of tolerance refer to Section 5.3 and repeat previous step. Note: An ac VTVM can be substituted for this and subsequent 3 db attenuation calibration steps.							
23.	Check phase calibration of HP dial at 200 cps	BP	20	X10	210	X1000	5	200 cps
	Adjust the HP SECTION dial to close the ellipse at approximately a 135 degree angle. Tolerance is a dial setting of 18 to 22. If out of tolerance proceed with the next step and then refer to Section 5.4.							
24.	3 db attenuation calibration of HP dial at 200 cps	BP	20	X10	210	X1000	5	200 cps
	Switch the HP SECTION frequency multiplier to the X1 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the HP SECTION frequency multiplier to the X10 position; adjust the HP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 18 to 22. If out of tolerance refer to Section 5.4 and repeat previous step.							
25.	Check phase calibration of HP dial at 2 kc	BP	200	X10	210	X1000	5	2kc
	Adjust the HP SECTION dial to close the ellipse at approximately a 135 degree angle. Tolerance is a dial setting of 180 to 220. If out of tolerance proceed with the next step and then refer to Section 5.4							
26.	3 db attenuation calibration of HP dial at 2kc	BP	200	X10	210	X1000	5	2kc
	Switch the HP SECTION frequency multiplier to the X1 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the HP SECTION frequency multiplier to the X10 position; adjust the HP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 180 to 220. If out of tolerance refer to Section 5.4 and repeat previous step.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
27.	3 db attenuation calibration at 60 on all bands, and 200 on X1000 band	BP	60	As noted	210	X1000	5	As noted

	Adjust Oscillator for scope vertical deflection of 20 divisions		Adjust HP SECTION dial for scope vertical deflection of 14 divisions (minus 3 db) with HP SECTION multiplier ON	If out of tolerance (dial setting of 54 to 66)
	Osc. Freq.	HP SECTION Multiplier		
a.	60kc	X100	X1000	Adjust C201, C211 or C220
b.	6kc	X10	X100	Adjust C202 or C212
c.	600 cps	X1	X10	Refer to step 22
d.	600 cps	X1	X1 With oscillator at 60 cps (check for oscillator amplitude variation between 60 cps and 600 cps)	Adjust C204 or C214

e. Repeat step 27a. using dial setting of 200 and oscillator frequency of 200kc. Tolerance is a dial setting of 180 to 220.

28.	Check phase calibration of LP dial at 600 cps	BP	20	X1	60	X10	5	600 cps

Connect scope horizontal input to oscillator output, and adjust scope for a sweep 20 divisions wide; remove scope horizontal input. Connect scope vertical input to oscillator output, and adjust scope for a line 20 divisions high. Connect the horizontal input to the cathode of V4B (V5A on rack model) through a 10μf (non-polarized) capacitor to remove dc level. Connect the filter OUTPUT to the scope vertical input. Adjust the LP SECTION dial to close the ellipse at approximately a 135 degree angle. Tolerance is a dial setting of 54 to 66. If out of tolerance, loosen set-screws and reset dial.

29.	3 db attenuation calibration of LP dial at 600 cps	BP	20	X1	60	X10	5	600 cps

Switch the LP SECTION frequency multiplier to the X100 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the LP SECTION frequency multiplier to the X10 position; adjust the LP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 54 to 66. If out of tolerance refer to Section 5.3 and repeat previous step.

30.	Check phase calibration of LP dial at 200 cps	BP	20	X1	20	X10	5	200 cps

Adjust the LP SECTION dial to close the ellipse of approximately a 135 degree angle. Tolerance is a dial setting of 18 to 22. If out of tolerance, proceed with the next step and then refer to Section 5.4

31.	3 db attenuation calibration of LP dial at 200 cps	BP	20	X1	20	X10	5	200 cps

Switch the LP SECTION frequency multiplier to the X100 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the LP SECTION frequency multiplier to the X10 position; adjust the LP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 18 to 22. If out of tolerance, refer to Section 5.4 and repeat previous step.

32.	Check phase calibration of LP dial at 2kc	BP	20	X1	200	X10	5	2kc

Adjust the LP SECTION dial to close the ellipse at approximately a 135 degree angle. Tolerance is a dial setting of 180 to 220. If out of tolerance, proceed with the next step and then refer to section 5.4.

Table 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
33.	3 db attenuation calibration of LP dial at 2kc	BP	20	X1	200	X10	5	2kc
	Switch the LP SECTION frequency multiplier to the X100 position; adjust the oscillator output for a scope vertical deflection of exactly 20 divisions. Return the LP SECTION frequency multiplier to the X10 position; adjust the LP SECTION dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of 180 to 220. If out of tolerance, refer to Section 5.4 and repeat previous step.							
34.	3 db attenuation calibration of LP dial at 60 on all bands, and 200 on X1000 band	BP	20	X1	60	As noted	5	As noted

	Adjust Oscillator for scope vertical deflection of 20 divisions		Adjust LP SECTION dial for scope vertical deflection of 14 divisions (minus 3 db) with LP SECTION multiplier ON	If out of tolerance (dial setting of 54 to 66)
	Osc. Freq.	LP SECTION Multiplier		
a.	60 cps	X10	X1	Adjust C304 or C314
b.	600 cps	X100	X10	Refer to Step 28
c.	6kc	X1000	X100	Adjust C302 or C312
d.	6kc	X1000	X1000 With oscillator at 60kc (check for oscillator amplitude variation between 6kc and 60kc)	Adjust C301, C311, or C330

e. Repeat step 34d. using a dial setting of 200 and frequencies of 20kc (setting 20 divisions) and 200kc (adjusting for 14 divisions - minus 3 db). Tolerance is a dial setting of 180 to 220.

Note: Remove 1,500 ohm resistor from Filter OUTPUT terminals.

35.	Check gain at 22 kc for narrowest band setting	BP	22	X1000	22	X1000	2.5	22kc
	Output signal should be between 1.0 and 1.5 volts.							
36.	Check HP corner peaking at 22kc in X1000 position	BP	22	X1000	66	X1000	2.5	22kc
	Output signal should be between 1.25 and 2.5 volts.							
37.	Check LP corner peaking at 22kc in X1000 position	BP	70	X100	22	X1000	2.5	22kc
	Output signal should be between 1.25 and 2.5 volts.							
38.	Check HP Filter components in X1000 position	BP	66	X1000	22	X1000	2.5	22kc
	Output signal should be between 0.009 and 0.033 volt.							
39.	Check pass-band gain for following settings:	BP	70	X100	66	X1000	2.5	22kc
		BP	20	X100	200	X100	2.5	6kc
		BP	20	X10	200	X10	2.5	600 cps
		BP	20	X1	200	X1	2.5	60 cps
	For each of above settings, output signal should be between 2.2 and 3.2 volts.							
40.	Check LP Filter section component for following settings:	BP	60	X1	20	X1	2.5	60 cps
		BP	60	X10	20	X10	2.5	600 cps
		BP	60	X100	20	X100	2.5	6kc
		BP	60	X1000	20	X1000	2.5	60kc
	For each of above settings, output signal should be between 0.01 and 0.05 volt.							

5.3 ALIGNMENT OF DIAL TUNING POTENTIOMETER ASSEMBLIES

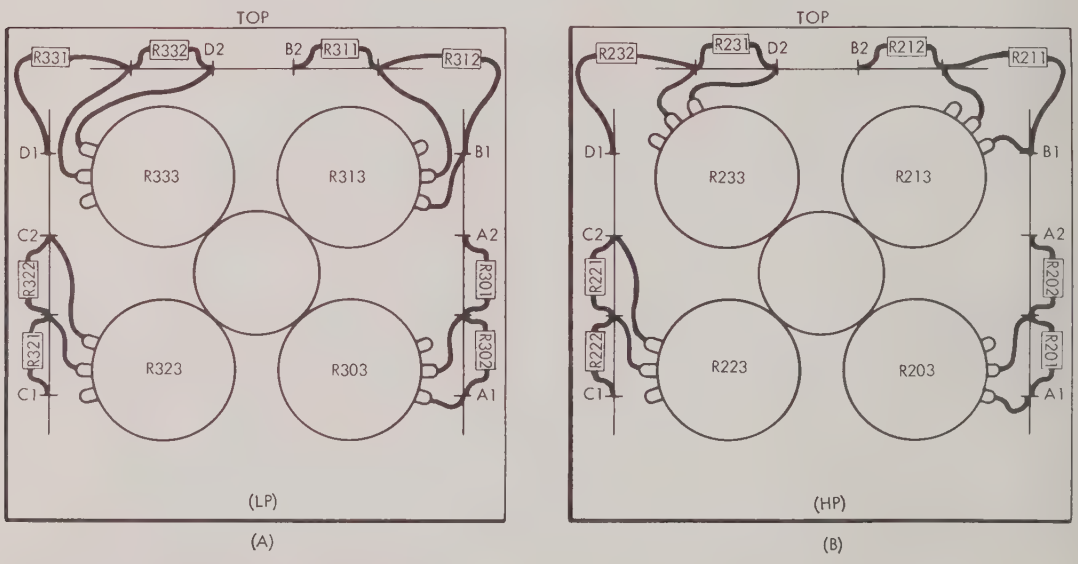
Figure 13A shows the rear view of the LP SECTION dial tuning potentiometer assembly, and Figure 13B shows the rear view of the HP SECTION dial tuning potentiometer assembly.

a. Set HIGH-PASS SECTION frequency dial (left-hand dial) to 60.

b. Connect a bridge between points A1-A2 (see Figure 13B) on the terminal board. The bridge should read 28.4K ohms ±5% (resistance of potentiometer R203).

c. Repeat step b for points B1-B2, C1-C2, and D1-D2 (see Figure 13B). The resistance measurements should be within ±5% of those readings in Table 3.

d. If the resistance limits of steps b and c cannot be obtained, adjust the HIGH-PASS SECTION frequency dial to see if all measurements fall within the limits of Table 3 at one setting. If they do, loosen the dial, slip dial to 60, and tighten. If all the resistances do not fall within limits at one setting, loosen the gear on the potentiometer that is off, and re-adjust until it falls within limits.



NOTE: ON THE RACK MODEL ONLY - THE LEADS FROM R303, R313, R323 AND R333 ARE WIRED REVERSE THAN SHOWN.

Figure 13. Rear View of Dial Tuning Potentiometer Assemblies

e. Set LOW-PASS SECTION frequency dial (right-hand dial) to 60.

f. Repeat steps b through c, but refer to Figure 13A. Slip dial or adjust individual potentiometer as described in step d as necessary to meet the limits of Table 3.

TABLE 3

LP SECTION AND HP SECTION POTENTIOMETER RESISTANCE MEASUREMENTS

LP Section Pot. Resistances*		HP Section Pot. Resistances*	
Connect bridge across	Should read (ohms ±5%)	Connect bridge across	Should read (ohms ±5%)
A1-A2	25.3K	A1-A2	28.4K
B1-B2	26.4K	B1-B2	23.9K
C1-C2	25.3K	C1-C2	28.4K
D1-D2	26.4K	D1-D2	23.9K

*All resistance values given include the fixed trimming resistor associated with each potentiometer. All resistance values should be measured on a bridge capable of reading to at least 1% accuracy.

5.4 ADJUSTMENT OF TRIM RESISTANCE OF TUNING POTENTIOMETERS

When the high and low ends of the LOW-PASS SECTION and HIGH-PASS SECTION dials do not calibrate with respect to the center-of-dial (60) position during the detailed test procedures described in Table 2, refer to Table 4 for adjustment of trim resistances for the appropriate tuning potentiometers.

TABLE 4

TRIM RESISTOR ADJUSTMENT FOR TUNING POTENTIOMETERS (FUNCTION SWITCH ON BAND-PASS)

Condition when Filter dial is adjusted for 180° phase shift*		Increase or decrease trim resistance as indicated below							
		HP SECTION potentiometers				LP SECTION potentiometers			
		Low end of dial		High end of dial		Low end of dial		High end of dial	
Dial Reading	Output Amplitude	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease
OK	LOW	R201	R211	R202	R212	R312	R302	R311	R301
		R221	R231	R222	R232	R332	R322	R331	R321
OK	HIGH	R211	R201	R212	R202	R302	R312	R301	R311
		R231	R221	R232	R222	R322	R332	R321	R331
LOW	LOW		R211,R231		R212,R232		R302,R322		R301,R321
HIGH	LOW	R201,R221		R202,R222		R312,R332		R311,R331	
LOW	HIGH		R201,R221		R202,R222		R312,R332		R311,R331
HIGH	HIGH	R211,R231		R212,R232		R302,R322		R301,R321	
LOW	OK		R201,R211		R202,R212		R302,R312		R301,R311
			or		or		or		or
			R221,R231		R222,R232		R322,R332		R321,R331
HIGH	OK	R201,R211		R202,R212		R302,R312		R301,R311	
		or		or		or		or	
		R221,R231		R222,R232		R322,R332		R321,R331	

*This is described in detail in the calibration of the HIGH-PASS SECTION and LOW-PASS SECTION dials of the detailed test procedure (see Table 2). The dial should agree with the input frequency when the phase shift is 180°, and the Filter output amplitude should be attenuated -3db from the nominal pass band gain when the phase shift is 180°.

SECTION 6

PARTS LIST

6.1 INTRODUCTION

This section provides listings for the replaceable parts of the Model 314(R) Variable Filter. The component parts are divided into three main headings: (1) Capacitors, (2) Resistors, and (3) Other Components.

The Manufacturers' Code and Part No. columns give the manufacturer and his part number for each component. The manufacturers' part numbers listed may differ from the part numbers of the components found in the instrument. These substitutions, however, are direct replacements.

6.2 MANUFACTURERS' CODE

MANUFACTURERS' CODE

Abbreviation	Manufacturer	Address
A-B	Allen-Bradley Company	Milwaukee 4, Wisconsin
BU	Bussman Mfg. Company	St. Louis, Missouri
C-D	Cornell-Dubilier Elec. Co.	South Plainfield, N. J.
C-H	Cutler-Hammer Inc.	Milwaukee, Wisconsin
CTS	Chicago Tel. Supply Corp.	Elkhart, Indiana
EL	Elmenco	Willimantic, Conn.
GE	General Electric Co.	Schenectady, New York
K-H	Krohn-Hite Corporation	Cambridge, Mass.
RCA	Radio Corp. of America	Harrison, N. J.
SP	Sprague Electric Company	North Adams, Mass.
Tel	Telefunken (c/o American Elite Inc.)	Long Island City, N. Y.

6.3 ORDERING PARTS

When ordering parts from the factory, the following information should be supplied:

1) Instrument Model Number

2) Serial Number of Instrument

3) Description

4) Manufacturer

5) Part Number

6.4 PARTS LIST

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
	CAPACITORS			
C101	0.047μf 10% 400V Mylar	1	C-D	WMF4S-47
C109	0.1μf 10% 400V Mylar	2	C-D	WMF-4P1G
C117	8 to 60μμf Variable Capacitor	1	EL	T-50410
C119	10μμf 5% 500V Mica	1	EL	DM15C150J
C120	47μμf 5% 500V Mica	1	El	DM15C470J
C122	39μμf 10% 500V Mica	1	EL	DM15C390K
C123	51μμf 5% 500V Mica	1	EL	DM15C510J
C124	120μμf 5% 500V Mica	1	EL	DM15C121J
C125	110μμf 5% 500V Mica	1	EL	DM15C111J
C126	39μμf 1% 500V Mica	1	EL	DM15C390F
C127	12μμf 10% 500V Mica	1	EL	DM15C120K
C128	1.5 to 20μμf Variable Capacitor	3	EL	T50210 Type 402
C129	14 to 150μμf Variable Capacitor	1	EL	T51410 Type 424
C201	51μμf 1% 500V Mica	1	EL	CM19C510F
C202	910μμf 1% 500V Mica	1	EL	CM19C911F
C203*	0.01μf 1% 100V Mylar	8	K-H	BCM-101
C204*	0.1μf 1% 100V Mylar	8	K-H	BCM-100
C205	0.01μf 10% 500V Mylar	2	C-D	WMF4S1G
C211	120μμf 1% 500V Mica	1	EL	CM19C121
C212*	0.001μf 1% 100V Mylar	7	K-H	BCM-102
C213	Same as C203			
C214	Same as C204			
C215	0.1μf 10% 200V Mylar	4	C-D	WMF2P1G
C220	Same as C128			
C221	27μμf 5% 500V Mica	1	EL	CM19C270J
C222	Same as C212			
C223	Same as C203			
C224	Same as C204			

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
C231	107μμf 1% 500V Mica	1	EL	CM19C107F
C232	Same as C212			
C233	Same as C203			
C234	Same as C204			
C235	Same as C215			
C240	150μμf 10% 500V Mica	1	EL	DM15C151K
C301	80μμf 1% 500V Mica	1	EL	CM19C800F
C302	Same as C212			
C303	Same as C203			
C304	Same as C204			
C305	Same as C215			
C311	31μμf 5% 500V Mica	1	EL	CM19C310J
C312	Same as C212			
C313	Same as C203			
C314	Same as C204			
C315	Same as C205			
C321	100μμf 1% 500V Mica	1	EL	CM19C101F
C322	Same as C212			
C323	Same as C203			
C324	Same as C204			
C330	Same as C128			
C331	24μμf 5% 500V Mica	1	EL	CM19C240J
C332	Same as C212			
C333	Same as C203			
C334	Same as C204			
C340	0.1μf 10% 400V Mylar	1	C-D	MFP4P1G
C404	0.001μf 10% 400V Mylar	1	C-D	WMF4D1(E)
C405A,B	200μf +50%-10% 200V Dual Electrolytic	1	SP	D33455
C501	Same as C215			
C502	Same as C109			
C503A,B	40μf +50%-10% 450V Dual Electrolytic	1	SP	17D15
C504	1μf 10% 400V Mylar	2	C-D	MMW-6W1
C505	Same as C504			
C506	1μf 20% 400V Oil	1	C-D	WC-4100-3
	RESISTORS			
R101	1K 10% 1/2W Composition	4	A-B	EB-1021
R102	200K 5% 1/2W Composition	1	A-B	EB-1245
R104	13K(TRIM) 5% 1/2W Composition	1	A-B	EB-1335
R106	1.5K 5% 1/2W Composition	1	A-B	EB-1525
R107	68K 5% 1/2W Composition	1	A-B	EB-6835
R109	100 ohm 20% 1/2W Composition	10	A-B	EB-1012
R110	1M 10% 1/2W Composition	2	A-B	EB-1051

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
R111	1K 5% 1/2W Composition	1	A-B	EB-1025
R112	82K 5% 1/2W Composition	1	A-B	EB-8235
R113	Same as R109			
R114	33K 5% 1/2W Composition	1	A-B	EB-3335
R117	39K(TRIM) 5% 1/2W Composition	1	A-B	EB-3935
R120	1.8K 5% 1/2W Composition	1	A-B	EB-1825
R122	16K 5% 1W Carbon	1	A-B	GB-1635
R123	15K 5% 1/2W Composition	1	A-B	EB-1535
R125	1.3K 5% 1/2W Composition	1	A-B	EB-1325
R126	47K 5% 1/2W Composition	1	A-B	EB-4735
R201	(TRIM) 1/2W Composition		A-B	
R202	(TRIM) 1/2W Composition		A-B	
R203	Under "OTHER COMPONENTS"			
R204	Same as R110			
R205	Same as R109			
R206	Same as R109			
R207	7.5K 5% 1/2W Composition	1	A-B	EB-7525
R208	560 ohm 5% 1/2W Composition	2	A-B	EB-5615
R211	(TRIM) 1/2W Composition		A-B	
R212	(TRIM) 1/2W Composition		A-B	
R213	Under "OTHER COMPONENTS"			
R214	3.9M 5% 1/2W Composition	2	A-B	EB-3955
R215	6.2M 5% 1/2W Composition	2	A-B	EB-6255
R216	Same as R109			
R217	Same as R208			
R218	22K 10% 1W Carbon	1	A-B	GB-2231
R221	(TRIM) 1/2W Composition		A-B	
R222	(TRIM) 1/2W Composition		A-B	
R223	Under "OTHER COMPONENTS"			
R226	Same as R109			
R228	22K 5% 1W Composition	1	A-B	GB-2235
R231	(TRIM) 1/2W Composition		A-B	
R232	(TRIM) 1/2W Composition		A-B	
R233	Under "OTHER COMPONENTS"			
R234	Same as R214			
R235	Same as R215			
R236	Same as R109			
R237	220 ohm 5% 1/2W Composition	1	A-B	EB-2215
R239	20K 5% 2W Composition	1	A-B	HB-2035
R240	20K 5% 1/2W Composition	1	A-B	EB-2435
R241	110K 5% 1/2W Composition	1	A-B	EB-1245
R301	(TRIM) 1/2W Composition		A-B	
R302	(TRIM) 1/2W Composition		A-B	
R303	Under "OTHER COMPONENTS"			
R305	9.1M 5% 1/2W Composition	1	A-B	EB-9155
R306	Same as R109			
R307	5.6M 5% 1/2W Composition	1	A-B	EB-5655

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
R308	910 ohm 5% 1/2W Composition	2	A-B	EB-9115
R309	27K 10% 1W Carbon	3	A-B	GB-2731
R311	(TRIM) 1/2W Composition		A-B	
R312	(TRIM) 1/2W Composition		A-B	
R313	Under "OTHER COMPONENTS"			
R316	470 ohm 10% 1/2W Composition	3	A-B	EB-4711
R318	Same as R309			
R321	(TRIM) 1/2W Composition		A-B	
R322	(TRIM) 1/2W Composition		A-B	
R323	Under "OTHER COMPONENTS"			
R326	Same as R316			
R328	Same as R308			
R329	Same as R309			
R331	(TRIM) 1/2W Composition		A-B	
R332	(TRIM) 1/2W Composition		A-B	
R333	Under "OTHER COMPONENTS"			
R336	Same as R316			
R338	8.2K 5% 10W Wire-wound	1	K-H	10S
R340	Same as R101			
R341	Same as R101			
R342	Same as R101			
R405	22K 10% 1/2W Composition	1	A-B	EB-2231
R406	4.3K 5% 1/2W Composition	1	A-B	EB-4325
R501	470K 10% 1/2W Composition	1	A-B	EB-4741
R502	Same as R109			
R503	Same as R109			
R504	10M 5% 1/2W Composition	1	A-B	EB-1065
R505	560K 5% 1/2W Composition	1	A-B	EB-5645
R506	22M 10% 1/2W Composition	1	A-B	EB-2261
R507	150K 10% 1/2W Composition	1	A-B	EB-1541
R508	Under "OTHER COMPONENTS"			
	OTHER COMPONENTS			
F501	Fuse, 1A, Slow-Blow		BU	MDL-1
F502	Fuse, 1/2A, Slow-Blow		BU	MDL-1/2
I501	Lamp, Pilot: a) Bench model	1	GE	#51
	b) Rack model	1	GE	#328
L501	Choke, 25HY at 75MA	1	K-H	C-100-6A
R203, R213, R223, R233	Potentiometers, Part of dial tuning potentiometer assembly K-H Part No. 315-HP	4	--	--

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
R303, R313, R323, R333	Potentiometers, Part of dial tuning potentiometer assembly K-H Part No. 315-LP	4	--	--
R508	Potentiometer, 500 ohms, 30%, 0.2W, Linear, WW	1	CTS	JF7516 Type 70
S100	Switch, rotary (function sel.)	1	K-H	314-2
S200	Switch, rotary (frequency sel.)	2	K-H	S1-310
S300	Same as S200			
S501	Switch, Toggle, SPST	1	C-H	8280K16
T501	Transformer, Power	1	K-H	P-100-14B
V1	Tube, Type ECC801S	2	Tel	ECC801S
V2, V3, V4, V5	Tube, Type 12AT7/ECC81	4	Tel	ECC81
V6	Tube, Type 6X5	1	RCA	6X5
V7	Tube, Type 6AU5	1	RCA	6AU5
V8	Same as V1			
V9	Tube, Type E88CC or 6922	1	Tel	E88CC or 6922

All voltage and resistance values should be measured from the pins of each socket to chassis ground with a VTVM having an input resistance of no less than 10 megohms. Voltages measured with instrument operating from a rated power source. Resistances measured with power line cord disconnected.

All measurements made with FUNCTION switch set at BAND-PASS; HP SECTION CUT-OFF FREQUENCY set at 50; LP SECTION CUT-OFF FREQUENCY set at 50; both multiplier switches set at X100 and the front panel INPUT terminals shorted.

All resistance values in ohms, K=1,000 ohms; M=1,000,000 ohms. Variations of up to 20% in all readings may be expected.

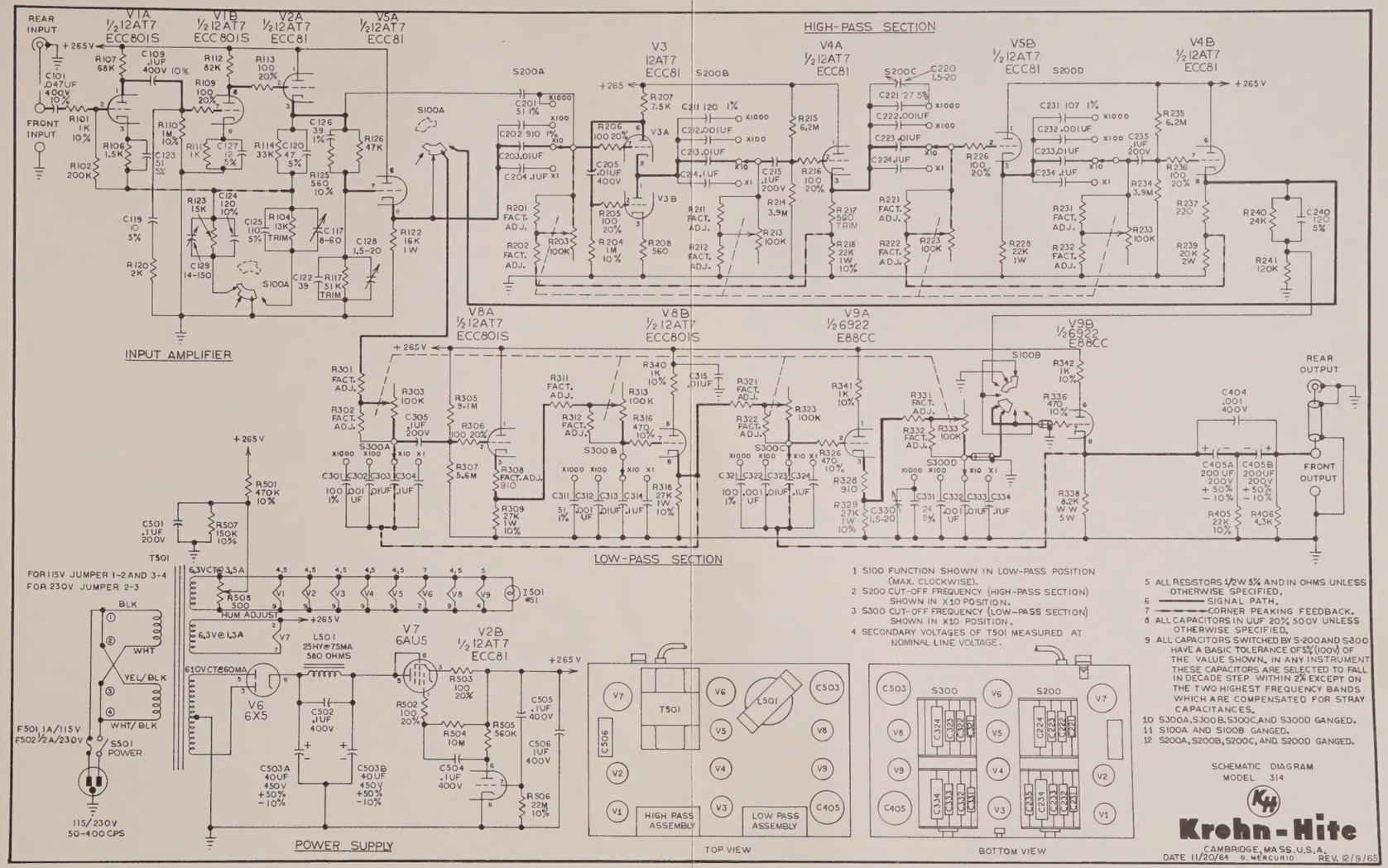
TUBE NO. & TYPE		PIN NUMBER								
		1	2	3	4	5	6	7	8	9
V1	V	175	46	49	†	†	125	0 ± 1	1.5 ± 1	†
	R	568K	200K	12K	130K	130K	582K	1M	1K	130K
V2	V	265	125	128	†	†	45	-1 ± 1	0	†
	R	500K	582K	30K	130K	130K	1M	22M	0	130K
V3	V	100	0	1	†	†	250	98	100	†
	R	>50M	1M	560 Ω	130K	130K	500K	70K ‡	750M	130K
V4	V	265	98	100	†	†	265	98	100	†
	R	500K	2.4M	23K	130K	130K	500K	2.4M	18K	130K
V5	V	265	90	93	†	†	265	58	60	†
	R	500K	60K ‡	21K	130K	130K	500K	28K	15K	130K
V6	V	---	†	305AC	---	305AC	---	†	360	---
	R	---	130K	173 Ω	---	173 Ω	---	130K	> 50M	---
V7	V	265	6.3AC*	270	---	335	---	6.3AC*	335	---
	R	10M	---	500K	---	> 50M	---	---	> 50M	---
V8	V	265	96	100	†	†	250	96	98	†
	R	500K	3.6M	28K	130K	130K	500K	53K ‡	27K	130K
V9	V	260	95	97	†	†	250	98	100	0
	R	500K	53K ‡	28K	130K	130K	500K	55K ‡	8K	0

* Measured between pins 2 & 7 of V7

† Will vary between 0 and 6.3vac depending on setting of R508

‡ May vary ± 30K

Figure 14. Schematic Diagram and Voltage-Resistance Chart, Model 314


INPUT AMPLIFIER
HIGH-PASS SECTION
LOW-PASS SECTION
POWER SUPPLY
TOP VIEW
BOTTOM VIEW
HIGH PASS ASSEMBLY
LOW PASS ASSEMBLY
1 S100 FUNCTION SHOWN IN LOW-PASS POSITION (MAX. CLOCKWISE).
2 S200 CUT-OFF FREQUENCY (HIGH-PASS SECTION) SHOWN IN X10 POSITION.
3 S300 CUT-OFF FREQUENCY (LOW-PASS SECTION) SHOWN IN X10 POSITION.
4 SECONDARY VOLTAGES OF T501 MEASURED AT NOMINAL LINE VOLTAGE.
5 ALL RESISTORS 1/2W 5% AND IN OHMS UNLESS OTHERWISE SPECIFIED.
6 ——— SIGNAL PATH.
7 ———— CORNER PEAKING FEEDBACK.
8 ALL CAPACITORS IN UUF 20% 500V UNLESS OTHERWISE SPECIFIED.
9 ALL CAPACITORS SWITCHED BY S-200 AND S300 HAVE A BASIC TOLERANCE OF 5% (100V) OF THE VALUE SHOWN, IN ANY INSTRUMENT THESE CAPACITORS ARE SELECTED TO FALL IN DECADE STEP WITHIN 2% EXCEPT ON THE TWO HIGHEST FREQUENCY BANDS WHICH ARE COMPENSATED FOR STRAY CAPACITANCES.
10 S300A, S300B, S300C, AND S300D GANGED.
11 S100A AND S100B GANGED.
12 S200A, S200B, S200C, AND S200D GANGED.
SCHEMATIC DIAGRAM
MODEL 314
Krohn-Hite
CAMBRIDGE, MASS. U.S.A.
DATE 11/20/64 B. MERCURIO
REV. 12/9/65

KROHN-HITE CORPORATION

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